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The Garrett Report

This long-awaited document—officially designated the "Report of the Joint Advisory Committee on Conditions in Ironfoundries"—has now been published by H.M. Stationery Office and costs 6d. The Committee were presided over by Mr. J. W. Gardom, the nominee of the Institution of British Foundrymen, who had associated with him seven nominees of the employers' federations and a like number of representatives of the trade unions and four from the Factory Department. Though no fewer than 65 recommendations have been made, there is nothing very revolutionary. In fact, it would be difficult to find a single recommendation that has not previously been commended in our columns. Many would introduce economies in manufacture, whilst for the balance, on a long-term view, they should not merely pay dividends, but make the foundry "a good place to work in," to quote an American slogan. Summarised, the Report rightly lays great stress on the reduction of dust in foundry practice, not so much on medical grounds, but with the laudable object of raising the level of cleanliness. It makes recommendations as to the elimination of coal- and coke-fired braziers for either general heating or for mould drying. Ladle drying should be carried out in properly allocated areas by modern methods. Fumes from core oils can be particularly obnoxious, and the Committee have tentatively dealt with this question. They seem to be a little nervous as to the use of mineral oils, as on a long-term prospect they may have a deleterious effect on the skin—even cancer is suggested. Quite definite recommendations are made as to washing and bathing facilities. There is no mention of "lavatories," so it can be presumed that this feature is taken care of by the "Factory Acts" or that the general situation is satisfactory—which we doubt. Whilst no recommendations are made as to the easing of castings, some very sensible practical suggestions are put forward; moreover, this is not an isolated case. Throughout the Report, there are many worthwhile suggestions not implemented by a recommendation, possibly owing to limited applicability.

The English of the Report is excellent, marred only by the use of the word "watched" instead of "controlled." "Watching" a process leads nowhere, but "controlling" ensures the desired results. The Report carries 17 recommendations to be observed when constructing new foundries. As the Iron and Steel Board may now withhold supplies of pig-iron and scrap to new concerns, there is little likelihood of new ironfoundries going into commission in the near future, though there are numerous cases of extensions and modernisations in progress, which presumably envisage higher outputs, involving increased consumption of raw materials.

We believe this is the first time that the employers and representatives of the trade unions within the foundry industry have ever produced a joint report, and it is pleasing to note that it is signed by every member. There is a sensible recognition of antiquity and all the drawbacks such conditions involve. There is, however, equal recognition of a determination by all to make working conditions of such a high standard that it will attract and retain the best type of workmen. We suggest that both the employers' federation and the trade unions should make it their business to see that this result of co-operative effort is brought to the notice of similar bodies abroad. The cost of amenities has to be taken care of in sales price—sometimes in the highly competitive international market, and here Britain may suffer unless pressure can be placed on overseas foundries to emulate the lead given by this Report.

Contents

The Garrett Report, 289.—Notes from the Branches, 290.—Correspondence, 290.—New Catalogues, 290.—Principles of Precision Investment Casting, Part III, 291.—Some Notes on Feeding, 297.—W. H. Whittle Foundation, 303.—John Brown & Company's Orders, 303.—Obituary, 303.—Imports and Exports of Iron and Steel, 304.—Company News, 305.—Personal, 308.—Raw Material Markets, 310.—Contracts Open, 310.—Heenan & Froude's Acquisition, 310.—News in Brief, 21.

Notes from the Branches

Birmingham, Coventry and West Midlands.

A meeting was held on July 24 at the James Watt Memorial Institute, Birmingham, to consider the formation of a Student Section. It was unanimously agreed to do so, and the distinction of being appointed the first Chairman fell to Mr. D. Marles. Mr. C. S. Vaughan was chosen for the office of secretary. A Committee, consisting of Mr. R. Jolly, Mr. M. H. Adamson, Mr. A. W. Matthews, and Mr. A. C. Edwards, was elected.

Mr. A. G. Harrison (Branch-President) said that for some time it had been felt by the Branch Council that more ought to be done to quicken the interest of the younger foundrymen in the affairs of the Institute. A sub-committee was accordingly appointed, with Mr. E. Hunter as Chairman, to explore the possibilities. The result was a decision to suggest the formation of a Student Section. Mr. Harrison detailed some of the practical advantages of being identified with the Institute and, on the social side, gave the assurance that friends would be found wherever a Branch was in existence.

Mr. Hunter emphasised that the Birmingham Branch, as one of the largest and most influential in the country, had special responsibilities, and said they felt the Branch must at all times uphold the high traditions of the Institute.

No institution could run for long unless there was an infusion of new blood. To maintain progress there must be a reserve of talent, and that such a reserve existed in the Birmingham area was beyond question. He estimated that there was a potential of 1,100 young people to draw upon. It seemed logical, therefore, to form a Student Section. He was gratified to be able to report that they could count on the co-operation of the technical colleges in the area. As to the objects of the new Section, these might be enumerated as follows:—To encourage younger members of the Institute (1) to take an active part in discussions; (2) to present Papers; (3) to prepare the younger members for the responsibilities of holding office in the Institute by serving as officers of the Student Section; (4) to encourage enthusiasm and develop a sense of moral responsibility towards the Institute; (5) to organise works visits; (6) to co-operate with the technical colleges so that the programmes of the Student Section would fall into line with the general theme of the technical college programmes; and (7) finally, to help to make foundrymen more fitted for positions of responsibility and trust within the industry.

While taking a paternal interest in the activities of the Section, Mr. Hunter made it clear that the Branch Council had no desire to control the Section. The Students' Section would be given a very free hand, but on matters of policy, it was essential that there should be no divergence from the general policy of the Institute. In matters of finance, the secretary and officers would be responsible to the Branch secretary. The matter of the programme for the Section had been discussed by the Sub-Committee. It was thought that, as the students were scattered over the Midland area, it would probably be advisable to hold the lectures at some of the technical colleges, and the latter had expressed their readiness to offer facilities. This was merely a suggestion, because it would be for the officers and committee of the Section to decide. The suggestion was that lectures should be arranged at Birmingham, Dudley and Wednesbury, which would even out travelling. It was felt that students would probably take a greater interest in works visits than some of the older members, and it was therefore recommended that a series of works visits should be arranged. During the first year, if requested, the Branch would assist in organising such visits, and in providing lectures. In conclusion, Mr. Hunter wished it to be understood that the fact that a Student Section had come into being did not mean that students were not permitted to take part in the activities of the Senior Section. Students would still be invited and would be welcomed at the senior meetings, and he hoped it would be found that some of the seniors would attend meetings of the Student Section.

After the decision to form the Section, conduct of the meeting was resigned into the hands of the Chairman of the new Section.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

LOAD-EXTENSION GRAPHS

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—Thanks for the review of my book "Workshop Engineering Calculations and Technical Science," in the June 12 issue of your JOURNAL. Your reviewer asks, "Why the sudden change in the axes of the load-extension graph"?

The object of a graph is to give a lucid picture of variable quantities, and the picture is most striking when the "dependent variable" is plotted vertically. This is stressed very much in the teaching of graphical work. I have seen graphs of other authors set with the axes as stated by your reviewer, but have always considered them queer when seeing the "load scale" vertical, and contrary to the generally accepted rule for graphical work. Strange would it seem to be to see a graph showing the variation of metal prices, with the "time scale" set vertically.—Yours, etc.,

F. STONEY.

New Catalogues

Ferro-alloys. Murex, Limited, of Rainham, Essex, have sent us three booklets on their metallurgical and chemical products, fine chemicals of tungsten, molybdenum and vanadium and nickel-hardened anti-friction metal. The latter possesses a typical heterogeneous bearing-metal microstructure and photomicrographs show that, even after repeated meltings, the structure undergoes no material alteration. Three leaflets were also received on powder metallurgy, molybdenum in cast iron, and various products of the company.

Principles of Precision Investment Casting*

Part III

By Kenneth Geist† and Robert M. Kerr, Jr.‡

Fig. 32 illustrates a machine employing vacuum in the casting. Of course, this can be used in combination with air or gas pressure on top. Obviously air pressure makes the casting, because when the vacuum is created, the atmospheric pressure forces the metal into place. There is a maximum pressure of, say, 14 lbs. Here again a good seal must be obtained.

The second type of machine to be used is the centrifugal casting machine. Fig. 33 shows a dental type of machine, in which very small castings may be made. The large arm with a jointed secondary arm attached to it is spun by spring pressure, the metal being thrown from the crucible into the mould. A motor may be substituted for the spring pressure.

Fig. 34 shows a very common type of production centrifugal casting machine. In this case, the crucible is located in the centre and usually four or more moulds are placed around the crucible. The whole device spins, and as it is spinning the metal is poured into the crucible and from the crucible it is thrown out into the mould. Now this may seem like a very logical way of centrifugal casting, but it has many disadvantages.

In the first place, a tight seal must be obtained between the crucible and the flask, otherwise metal will escape. Secondly, as the machine is loaded, the flasks cool rather rapidly and a careless workman could allow them to cool down considerably, causing inaccuracy in dimensions. It is usually rather difficult to get these moulds into place without jarring them, and damage to the investment may result. Finally, it is almost impossible to balance this type of casting machine because of the unequal speed with which the four moulds are usually filled due to the way the metal is poured, the shape of the crucible, and the fact that usually the cavities of the four moulds are not exactly the same, and more metal will enter one than the others. This throws the machine off-balance, causes vibration, and the vibration may cause hot tears in the casting, as well as dirt from the broken parts of the mould.

Centrifugal casting machines are used primarily because higher pressure can be developed than are possible in the air or gas type pressure machines available. As a matter of fact, the pressure in any centrifugal casting machine is only limited by the strength of the investment. Also, the force is in the metal itself rather than being applied from behind, so that as long as there is molten metal there is pressure being applied. In a pressure-type casting, if a leak should occur then all the pressure would be lost.

Fig. 35 shows a schematic diagram of a vertical tubular type of a production centrifugal casting machine. Here there is a tube with a shaft around which it rotates; (*b*) is a crucible full of molten metal; (*a*) is a mould inverted on top of the crucible; (*c*) is the retaining cap to hold the mould in place; (*f*) is an adjustable weight to counterbalance the crucible and mould so that the machine will be in balance.

This machine operates by revolving, and obviously the first action is not centrifugal but pouring as the tube inverts. In other words, (*t*) goes down to where (*g*) is on the first half revolution. The metal is poured from the crucible (*b*) into the opening of the mould (*a*) so that a very gentle action is obtained. As the tube continues to revolve and picks up speed, the centrifugal force is brought to bear with the least possible disturbance to the metal. The result, of course, is a very sound casting with no vibration.

FIG. 32.—VACUUM MACHINE.

*Exchange Paper of the American Foundrymen's Association, presented at the 44th Annual Conference of the Institute of British Foundrymen at Nottingham, June 19.

†Technical engineer in charge of precision casting at Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin.

‡President, Kerr Manufacturing Company, Detroit, Michigan.

Precision Investment Casting

In some machine shops no casting machines of any sort are used. These shops depend upon the static pressure of the metal to complete the casting and to feed the shrinkage.

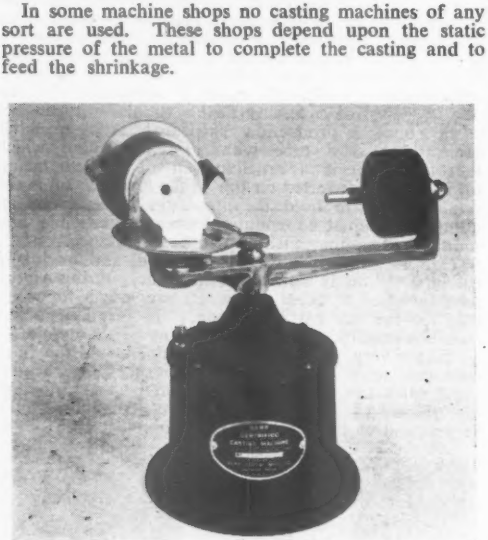

FIG. 33.—DENTAL TYPE OF MACHINE.

10. *Cleaning and Surface Testing.*

When the moulds are cold the castings are knocked out and cut off from the sprues. The gates are cut down flush with the castings according to accepted foundry practice. After the gates are cut off and ground the surface of the castings is frequently treated in order to give a better appearance. This is done by either treating with a very fine sand blast, tumbling, or Wheelabrating.

III. PLANT LAYOUT

Since precision casting is a tool, in fact a precision tool, it should not be entered into on a shoe string. Like all precision work, a well equipped plant is necessary. Thus the plant must not only have proper machinery and personnel for making castings, but should also have a good engineering department, a good estimating department, proper cost accounting personnel, and at least one experienced metallurgist. It has been estimated that even for a small plant, the installation cost would be £6,000 to £12,000 and at least that amount in working capital.

Many of the troubles of precision casters are traceable to firms that have tried to get along on a shoe string and have not done true precision work. Many of them have been doing little better than glorified sand casting. Fig. 36 shows a typical flow sheet with the layout of most of the equipment required.

IV. DESIGN FACTORS

It is not possible at present to set forth a definite formulæ for casting design. It is, however, possible to state that castings made in conformity with certain basic principles will be capable of economical production.

The first basic principle is; the piece should be designed so that progressive solidification can take place. This means that the casting section should be so proportioned that the sections most distant from the point where the casting is to be fed, will solidify first, with the solidification progressing toward the gate or risers where the hottest metal is located. With this in mind, the designer should be extremely hesitant to isolate any appreciably heavy sections or locate them where they cannot be adequately fed, since the use of chills, or any other such artifices, as are commonly used in the regular foundries, are either difficult or impossible to use in the lost wax process. Further discussion on this problem will be found in the section covering metallurgical problems.

The second basic principle to be observed is the linear shrinkage or the contraction occurring during cooling from the solidification temperature to room temperature. This is the contraction that ordinarily is compensated for by the pattern makers shrinkage allowance. Casting should be so designed that essential mould rigidity and resistance due to irregular casting shapes will not result in severe contraction stresses which, due to the different cooling rates of thin and heavy sections could easily result in hot tears or severe residual stresses.

The best practice in designing castings is to use the minimum section thicknesses that will provide the neces-

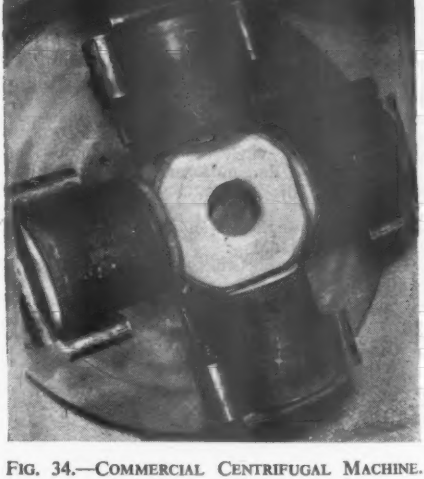

FIG. 34.—COMMERCIAL CENTRIFUGAL MACHINE.

sary strength. These sections must not, however, be so thin as to cause difficulty in filling out the casting. The excessive temperatures required in this case will cause poor physical properties.

The best time to think about utilising the precision investment casting process is before the piece is on the drafting board. When it is in the planning stage, a part can be modified to fit whatever production method is selected for it. Changes leading to reduction in cost and improvement in its performance are easier to make. Since the same laws of physical metallurgy which apply to large castings, apply to precision castings, it is a good idea to make the drawing 5 or 10 times actual size and treat the part just as one would treat a large casting. Design it into the strongest and lightest weight and thinnest section casting adequate for its service factors, using ribs, fillets, and all other strengthening design members in it. Since the cost of the materials is almost negligible, the piece should be designed so as to utilise the strongest obtainable alloys, or the corrosion and abrasion resistant factors of the most resistant metals in accordance with the service conditions which the piece is to meet. It is also a good policy to draw in the gating system on the enlarged print, since the gating and risering problems of precision casting are almost identical to those of the larger castings.

When the enlarged drawing appears to be satisfactory, it should be reduced to actual size and rechecked to make sure that the casting is within the limitations of the process. If found to be outside of those limitations of the contracting shop, the drawing should be corrected. Following this procedure, anyone who can design for regular castings, can probably design for precision casting.

At the present time the average shop seems to be set up to cast no dimensions larger than 5 in., no weight of a single casting greater than 5 lb., and no section continuously thicker than ½ in. or thinner than 0.030 in. The typical precision investment casting weighs ½ lb. or less, has no dimension longer than 2 in., and has no thickness greater than ½ in. Prices per piece or per lb. of completed castings seem to be lowest in this range, the price rising out of proportion to the increase in size in larger pieces. The dimensions given above are by no means the limit since many larger castings are being made.

There has been considerable misunderstanding as to the thickness of section which is castable by this process. Briefly, it can be stated that sections 0.25 in. long by 0.125 in. wide have been cast 0.005 in. thick. Sections 1 in. long by 1 in. wide have been cast 0.025 in. thick. Sections 0.040 in. thick seem to be castable to any length and width that the investment flask will take. When a section is not a continuous thickness, but is in successive gradient of thickness, it is practical to bring the thinnest edge down to 0.015 in. or even less. The steam turbine blade is a good example of this.

Holes, recesses, and chambers of almost any size and shape can be cast as long as the pins or loose pieces can be removed from the wax pattern. Small holes down to 0.050 in. diameter can be cored into castings by almost any shop. Even smaller diameters can be produced, depending upon their lengths, their locations, their depths, and whether or not they are open at both ends so the tiny rods of investment, which will keep them open as the castings are poured, will be supported at both ends. Threads, either internal or external can be cast, although it is rather difficult to cast threads less than 12 threads per inch, or smaller than ¼ in. thick at the roots. Very seldom are there accuracies closer than a class 2 fit. Since the process is generally limited to accuracy in order of plus or minus 0.003 in. per inch of dimension, it is easier to cast contours of thread, and of gear teeth of similar shape than it is to hold their accuracy.

There seems to be little doubt as to the details of contours and finishes which this process can produce. Dimensional accuracy of these contours is another matter, however, accuracy can be of several kinds.

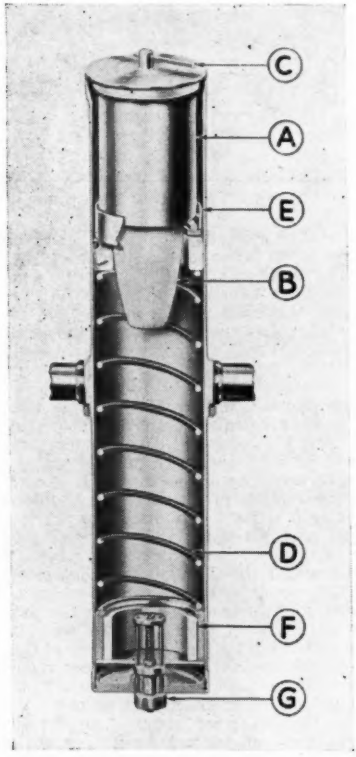

FIG. 35.—VERTICAL TUBULAR TYPE CENTRIFUGAL CASTING MACHINE.

Precision Investment Casting

dimensional, parallel, angular, contour, and surface finish. Since most of the accuracies on current blueprints are those to which the highly accurate machine tools automatically cut the casting producers are very wary of the whole subject of accuracy. The problem is not that of providing necessary accuracy, but of meeting customers' specifications of unnecessary accuracy.

The query as to what tolerances can be held in casting is probably the most frequently asked question a precision caster must answer. The average of the whole process would work out to "as cast" tolerances of +0.003 in. to +0.006 in. per inch with plus or minus 0.001 in. on the small dimensions the very finest tolerance, but with plus or minus 0.0005 in. or even 0.00025 in. obtainable on some dimensions made of certain alloys. The non-ferrous alloys generally seem to be castable to finer tolerances than the ferrous alloys. No tolerance finer than plus or minus 0.003 in. should be demanded unless there is a compelling reason for it. If a blueprint calls for a few very close tolerances that cannot be held during the casting operation, a secondary operation might be feasible and still make the casting economically profitable. An important factor in considering tolerances is the factor called size relation. Fig. 37 showed two simple geometric figures, a 1 in. cube and a 12 in. bar. Normally, in machining, it would be just as easy to hold a tolerance of plus or minus 0.010 in. on either one of these figures, but in casting it is not. Assuming that the metal cast has a 2 per cent. shrinkage and no provision is made for this shrinkage in the casting, then if the 12 in. piece would shrink 0.240, the 1 in. piece would shrink 0.020, so it is going to be a much more difficult task to hold the tolerances on the long piece than it is on the short piece. This is what is meant by size relationship. Fig. 38 illustrates this same relationship Dimension A would present no problem since it is very small. Dimension B, would, however, and so would the other dimensions on this piece. This is because the blueprint states "unless otherwise shown, tolerances on decimal dimensions are plus or minus 0.010 in." That is easy to hold on dimension A, very difficult on B. so that if one can allow greater tolerances on B, be sure and indicate that to precision casting plant. If close tolerances are necessary in B, expect higher castings costs than if they are not.

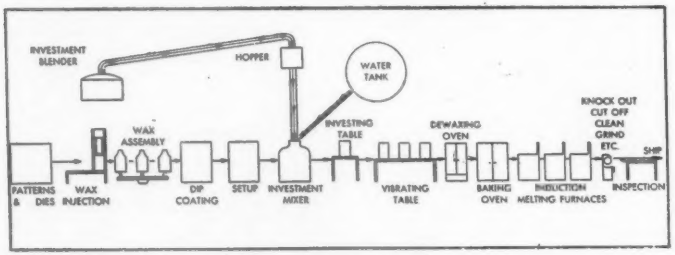

FIG. 36.—FLOW SHEET FOR PRODUCTION.

V. METALLURGICAL AND FOUNDRY FACTORS AFFECTING DESIGN

Probably one of the most important problems is the determining of the proper gating system for the casting. This problem is very complicated in some cases, especially if wax is used as an expendable pattern. What frequently may be the most ideal gating system as far as solidification of the metal is concerned, may be entirely impractical as far as assembling the wax patterns and the investing is concerned. One of the chief disadvantages of using wax as a pattern material is its fragility. If investments requiring vibrating in order to secure a pack are used, it is quite necessary that the wax assembly be very substantial to resist the tendency to break during the vibrating period; hence, many types of bottom gating and small gates are not practical because they are not strong enough in the wax assembly. If an investment requiring vibration to eliminate air and provide the necessary packing is used, it is necessary to arrange the pattern in the mould so as to avoid entrapping any air which might rise from the mixture. This positioning in the mould frequently forces the metallurgist to compromise on his gating system.

The most important function of the gating system is to provide entry for the metal into the mould so that the progressive solidification can take place. The metal in the farthest part of the casting should solidify first and then solidify progressively toward the gate so that any porosity due to shrinkage will be confined to the gates and risers rather than in the casting. If the metal is fed through a thin section into a thick section, the thin section would solidify first leaving nothing for the thick section to draw from, hence the thick section would be porous. Therefore, the thick section should be closest to the gate or to the sprue. If this is impossible, blind buttons or risers should be placed on the heavy portion. The gates into the casting should be as short and bulky as pos-

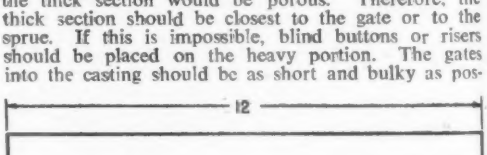

FIG. 37.—SIZE RELATIONSHIP.

sible so that they will solidify last producing a solid casting. One of the great advantages of this process is that almost any metal which is castable can be cast into one or more of the moulds employed by the process. There are some problems, however, which are not found in other methods of casting which must be watched. First of these is that certain metals attack the surface of the moulds. Those moulds containing considerable amounts of plaster are frequently attacked by metals containing more than 5 per cent. lead. A lead sulphide film is formed on the surface of the casting which, when sand blasted off, leaves a relatively rough finish. Some of the low alloy, low carbon steels such as SAE-1010, or SAE-1020 also frequently attack the surface of the mould resulting in a pitted and very irregular surface. It appears that the addition of only 1 or 2 per cent. alloys to this steel

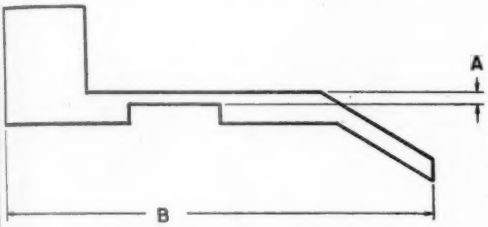

FIG. 38.—DIMENSIONAL TOLERANCES (UNLESS OTHERWISE SHOWN, TOLERANCE ON FRACTIONAL DIMENSION: ± 0.010.

alleviates this condition permitting the obtaining of a fine surface. The surface of the mould is also attacked by pouring at extremely high temperature, resulting in a pitted and slagged surface due to the fusing in of the surface to the casting. It is also attacked by some waxes and, of course, any quantity of iron in the alloy will be badly attacked by sulphur if investment contains plaster.

In some cases the slow cooling of the mould also produces a problem. This slow cooling results in a very course grain structure of the metals, and in cases where a fine grain structure is necessary, additional heat treatments such as normalising are required, in order to refine the grain size.

Another factor which must be dealt with, when using metals dependent upon carbon to produce hardness, is the decarburised layer of the surface of the casting. This decarburised layer may be anywhere from 0.005 in. to 0.020 in. in depth. There are several ways to overcome this problem. The first is to inject an inert gas or a reducing gas into the mould just prior to the pouring operation. The second method is to restore the carbon in the decarburised layer of the casting, either in a salt bath or by some carburising treatment. If the casting is to be machined it is also possible that the decarburised layer may be removed during the machining operation.

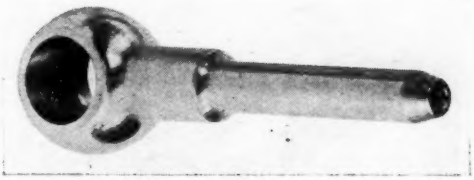

FIG. 39.—CASTING REPLACING A MACHINED COMPONENT.

VI. DESIGN

In the next three figures it is desired to discuss the feasibility of casting three different types of parts. Fig. 39 shows a part which was normally made on a screw machine with a secondary drilling operation. In any sizeable production, that would not be a feasible precision casting proposition, because it could be turned out very cheaply by a screw machine operation, but for an order for 50 they could be made more cheaply by precision casting using a soft metal die, rather than to take up the time to set up a hand screw machine or a lathe. So, for a limited production or model-making a sample to try out a new design, precision casting would be satisfactory. The cheapest method with any sizeable production quantity would be on the screw machine. Fig. 40 shows a forging and a screw machine part. Precision casting would not make the forging cheaper, except in very limited production. The screw machine parts obviously, could not be made cheaper except in very limited production. However, if the two were com-

FIG. 40.—FORGING AND SCREW MACHINE PART.

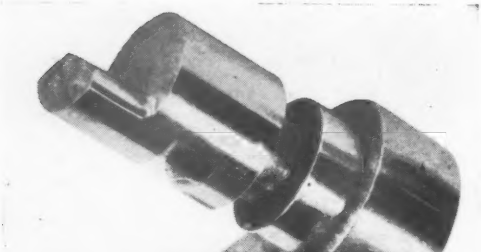

FIG. 41.—THE COMPONENTS SHOWN IN FIG. 40 CAST INTEGRALLY.

bined and cast in one piece, there is a possibility of making the piece more cheaply by precision casting than by the combination of forging and screw machine parts. Hence, it might be possible to make this part cheaper by precision casting, simply because of eliminating the assembly operation (Fig. 41).

Fig. 42 illustrates an agitator vane and clamp for a paper stock pump, which is ideal as a precision casting, either in small or large quantities. According to the design of the vane, it is obvious that to machine these splines would be a costly operation, even in fairly high production. As a precision casting, the two parts can be fitted with no machine operations at all.

VII. SUMMARY

To summarise, precision casting is an ideal process for producing intricate parts in either small or large quantities, with smooth surfaces, with metal and physical properties characteristics equivalent to machined parts, and to fairly close tolerances. It is especially useful in the higher temperature metals such as steel, and the refractory metals used in the gas turbine and jet turbine fields. The harder the metal the more advantageous is the application of precision casting. Likewise, the more machine operations which can be eliminated, the more advantageous is the application of precision casting. It is not an inexpensive process such as die casting.

Remember that in die casting, the die casting plant has the casting completed in the same number of steps as the precision casting plant takes to make a wax pattern. A precision caster injects wax into a metal mould and then starts from there. A die caster injects metal into a metal mould and the casting is completed. Precision casting can handle practically any metal that can be cast at all, and handles with ease metals that are difficult or even impossible to fabricate economically by other methods. It is not a process that just anyone can operate, either in his garage or in a factory. In order to produce quantities of precision parts, elaborate and expensive controls must be set up and maintained. It is these controls which account for the major portion of the costs on precision castings.

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Austenal Laboratories, Inc., New York City, N.Y.
Whip Mix Corporation, Louisville, Kentucky.
Carbide & Carbon Chemicals Corporation, New York City, N.Y.
J. Yates Dental Mfg. Co., Chicago, Illinois.
Edwin Laird Cady, Feature Writer, Reinhold Pub. Co.
Bureau of Standards.

FIG. 42.—AGITATOR VANE.

Winget Life—Summer 1947. Produced by Winget Limited, Rochester, price 6d.

This well-laid-out 20-page publication contains a short article, "My experiences at the International Meehanite Training School for Foundry Apprentices," which will give an idea to prospective trainees of the type of training they might expect. A member of the Winget Company reviews modern equipment for constructional projects, while other items, including some good caricatures, are largely personal.

Some Notes on Feeding*

By S. L. Finch†

SUMMARY

An outline of crystallisation, solidification and subsequent shrinkage is given. The growth of metallic crystals is outlined in an elementary manner and brief notes are made on the various effects of alloy composition, latent heat of fusion, specific heat and gas content as related to the mechanism of freezing.

Directional solidification and temperature gradients are reviewed with regard to the Heuver principle and the use of insulating pads and feeding fluxes.

The flow of liquid alloy from a feeder head to the casting is discussed taking into consideration such variables as friction of crystal growth, fluidity and head pressure. The effect of this flow on segregation is mentioned in relation to the mechanism of freezing. The effect of rate of feed demand on head efficiency is outlined.

Finally some theories are advanced as to some possible ways of applying feeder heads in the future when it is expected that the present uncertainty of feeding will be replaced by more economic and efficient methods.

Introduction

The past few years have seen many advances in foundry practice. Progress and developments have been made chiefly because the founder realised that foundry practice was not only a craft but that it offered to the scientist a tremendous field of opportunity for research and subsequent development. Not least amongst these scientific studies has been the analysis of some of the factors influencing the feeding of solidifying alloys. Some of the fundamental basic laws which govern feeding were established, but these merely revealed the almost complete lack of data on this subject.

The recent war years have seen efforts made to discover the true facts so that a more complete understanding of this aspect of foundry practice could be established. Whilst considerable success has been achieved, this has led to the realisation of just how many variables do affect feeding efficiency. This Paper is not meant to give any further experimental or practical evidence of feeding technique but rather is an attempt to correlate certain practices with known theories, and also to offer some theories, which unfortunately cannot be proved or disproved because of lack of data. However, time will reveal these shortcomings but only co-operative research on a large scale can lift the veil of misunderstanding.

In order that several recent discoveries may be reviewed, it is essential to deal with some of the variables affecting feeding efficiency. It is always a difficult task to name these variables and place them in order of importance, but consideration of the following sections (which all undoubtedly affect feeding efficiency) will serve as a basis for theoretical assumptions and recommended practices: (A) The mechanisation of crystallisation, solidification, and subsequent shrinkage; (B) directional solidification and temperature gradient; and (C) flow of liquid from feeder head to casting.

*A Paper presented at the Nottingham Conference of the Institute of British Foundrymen.

†Foundry Manager, Catton & Co., Leeds.

(A) Mechanisation of Crystallisation, Solidification and Subsequent Shrinkage

Although the facts concerning crystallisation and solidification are generally well known, it is essential to discuss these in an elementary manner, to serve as a basis for further portions of the Paper. Additionally some comments are made in the following paragraphs which reveal the complexity of the problem of establishing efficient feeding. Each of the following has some bearing on crystallisation and solidification and each probably affects feeding efficiency to a greater or less degree:—(1) the growth of metallic crystals; (2) alloy composition; (3) supercooling; (4) latent heat of fusion; (5) specific heat; (6) gas content; and (7) form of shrinkage.

(1) *Growth of Metallic Crystals*

In considering the crystallisation of a metallic liquid the first stage must be the study of metallic growth as it would occur in a mass of liquid whose container would have no effect on crystallisation procedure.

In a liquid which is at a temperature considerably above the melting point, the atoms are constantly under the force of repulsion and although contacts are constantly being made, no combination takes place. As the temperature of the liquid drops, the movement of the atoms become slower, and the forces of repulsion are decreasing. As the freezing point is approached the atoms have a tendency to combine and to assume their space lattice formation. This state is, however, unstable, and they have only a temporary existence and until the liquid temperature falls, there is no increase in their stability. As the temperature falls so does the stability of these fragments increase. At a certain temperature this stability is established and the fragments form their appropriate space lattices and attach themselves to other atoms. This stage marks the commencement of crystallisation.

From the formation of the atomic and foreign nuclei, crystal growth commences. As an example liquid iron crystallises in the cubic form and the octahedron appears to be the crystalline form of gamma and delta iron, growth occurring preferentially in the direction of the axis of the system.

Associated with octahedral crystalline growth is the formation of the usual six branched primary skeleton. Whilst the formation of these branches is caused by the force of crystallisation, their cross section is of a circular nature because of the effect of surface tension. What may be termed the second stage of crystallisation

Some Notes on Feeding

is the formation of secondary skeleton branches from the primary ones and the growth of the former proceeds parallel with those of the latter. Tertiary branches next begin to form and the final crystal formation begins to occur. As all these branches begin to form two other factors influence crystallisation (*a*) the initial branches of the skeleton begin to thicken up and (*b*) the last branches to be thrown out begin to restrict the growth of their neighbours. Thus two forms of crystallisation are possible, (1) the formation of a complete skeleton of primary, secondary, tertiary, etc. branches surrounded by liquid or (2) that the thickening up of the branches occurs as quickly as the formation of secondary branches, thus resulting in progressive formation of a solid rather than extensive skeleton growth.

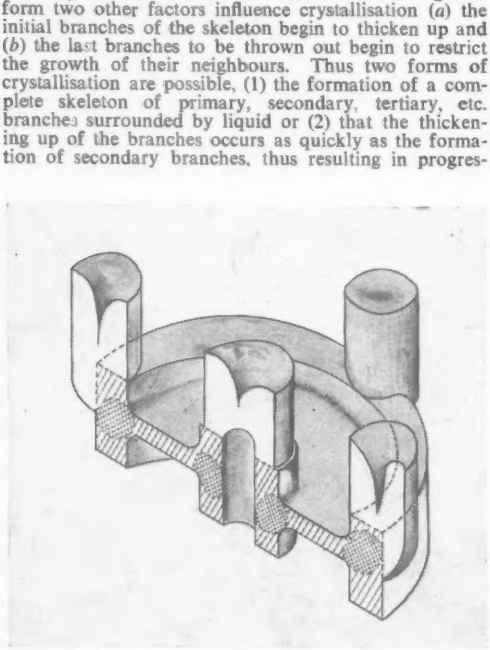

FIG. 1.—GEAR BLOCK CASTING.

The range between these two extremes is governed by the solidification range of the alloy. Thus with varying ranges of solidification a consistent formation of skeleton growth in the various alloys does not occur and the type of growth will be found to be a compromise between case (1) and (2). Thus metallic alloys generally solidify first by the formation of skeleton growth and some thickening up of the branches, followed by the final stage where liquid metal is supplied before the final stage of thickening up to fill all the interstices. It is this last aspect of crystallisation which will be found to be most important when related to feeding. This consideration of unadulterated crystal growth must now be considered in the solidification procedure which occurs in a mould.

Crystallisation in a Mould

When a liquid alloy is poured into a sand mould there is formed fairly quickly a very thin shell of chilled material. It is from this chilled alloy that crystallisation first commences. As in the theoretical case, crystalline growth commences by the formation of skeleton branches surrounded by liquid. Thus the primary skeleton branches are surrounded by a liquid of lower melting point. Skeleton branches are, then, proceeding from the mould face into the centre, the interstices being surrounded by metal of lower freezing range which has been slightly heated or at least had its cooling rate retarded by the dissipation of heat from the skeleton branches on solidification. This takes place progressively from the outside of the mould face to the interior. It is this skeleton growth which introduces complications in the feeding of castings. If solidification was completed by the formation of even layers of solid matter, trouble as a result of inefficient feeding would not be as prevalent as it is. At any stage after skeleton growth has commenced the farthest advanced portion of the solid consists only of crystal skeletons, completely solid metal having formed some considerable distance nearer the cooling mould face. Consequently the metal in the mould may be divided into three zones:—

(1) The solid zone on the outside;

(2) The mushy zone consisting of skeleton crystals in the liquid. (By mushy zone the Author wishes to convey the description of liquid plus solid crystals. This should not be confused with viscosity); and

(3) The liquid zone. (It should be pointed out that these zones merge into each other and are not distinct layers.) In pure metals and eutectics which solidify at constant temperatures the second zone is practically non-existent, and the effect of skeleton growth is at a minimum because of the absence of selective freezing. In solid solutions, the second zone is wider and its width increases with increase in the temperature interval between the liquidus and solidus and with decrease in temperature gradient.

During solidification the three zones may be distinguished as the solid zone nearest the mould face and this advances with the isotherm representing the solidus, the advance of the second zone keeps up with the iso-thermal line representing the liquidus. With a given temperature gradient the actual width of the mushy zone must increase with the difference between the liquidus and the solidus, and with a given range of solidification, the width of the mushy zone must increase with decrease in the temperature gradient. The effect of latent and specific heat values will also control the width of the mushy zone.

Considering this from the practical aspect, the effect in certain types of castings will be considerably varied. Where the section is thin and uniform and where there is a relatively large surface area to volume there will be a steep temperature gradient, the mushy zone will be small. As the surface area to volume ratio decreases so the rate of cooling will decrease and the temperature gradient will be lowered, increasing the mushy zone.

Keeping these two variables in mind, consider the effect of increasing section. The rate of solidification will be decreased and as a consequence so will the temperature gradient, resulting in an increased mushy zone. The effect of composition on the mushy zone becomes increasingly obvious in that any added element which increases the soldification range automatically increases the mushy zone, all other variables being constant.

As crystallisation occurs in the manner described, a certain amount of "free" growth probably occurs in the core of the section. As these skeleton branches form, as a result of their higher density they tend to drop in the direction of the force of gravity. Recent experimental work carried out by B.I.S.R.A. reveals that this has considerable influence on the mode of crystallisation of steel in a mould. Columnar crystals grow from the roof of the mould whilst equi-axial or nuclear crystals persist in the lower portion. The latter is caused by the "smothering" effect of falling nuclear crystals.

As skeleton growth occurs, the crystal branches are surrounded by a liquid varying in composition, the degree of variation being purely dependent on the initial alloy. The branches of the skeleton begin to gradually thicken at the expense of the surrounding liquid metal. At the same time the advance of the zone of the skeleton growth continues. As the liquid surrounding the skeleton branches solidifies it contracts in volume and thus the voids must be filled by metal which is filling the interstices of more recently born skeleton growths. This in turn must be compensated by the flow of liquid from the interior, but as will be shown later, many factors probably control this flow.

This procedure continues until finally the skeleton branches from opposite or adjoining mould faces meet and the intersticial spaces are filled by metal flowing from the portion of the mould which is still liquid. It is realised that more advanced theories concerning crystallisation are under consideration, but these will not in any way alter the general principles. This very elementary outline of crystallisation had, however, to be given as a basis for certain theories which are considered in this Paper in relation to efficient feeding.

(2) *Alloy Composition*

Alloy composition does affect feeding potentialities and complexities. The effect of composition on fluidity has been sufficiently studied to give some conclusions. Bastien[5] proved that the fluidity of a series of alloys varies inversely with their respective solidification ranges. Pure metals and eutectics of a series have the best fluidity, whilst saturated solid solutions are relatively lower. Consequently, other variables being constant, alloys approaching pure metals or eutectics have a higher fluidity, and are easier to feed than alloys which consist of saturated solid solutions.

Whilst alloy composition governs solidification range, it also controls the amount of liquid and solid present at different stages during solidification. The effect of increase in solidification range does of course increase feeding problems as can be gathered from the discussion on crystallisation as well as its effect on fluidity. Obviously the greater the distance between liquidus and solidus, the greater the mushy zone. However, what crystallisation studies do not at first reveal is that the greater the amount of liquid present in a solidifying alloy, the less microshrinkage that occurs as a result of the dendritic growth. Consequently two different alloys which have the same solidification range may differ considerably in soundness. This is because of one having at the lower end of the solidification range a greater amount of liquid present, the other one having a larger amount of solid and less liquid, consequently the latter is more prone to microshrinkage.[1]

These two points, *i.e.*, effect the solidification range and the shape of the liquidus and solidus lines have been proved experimentally. Indeed, it was shown in the case of magnesium alloys that although one alloy had a shorter solidification range than another, it was more susceptible to microporosity because it contained far less liquid in the lower portion of its solidification range.

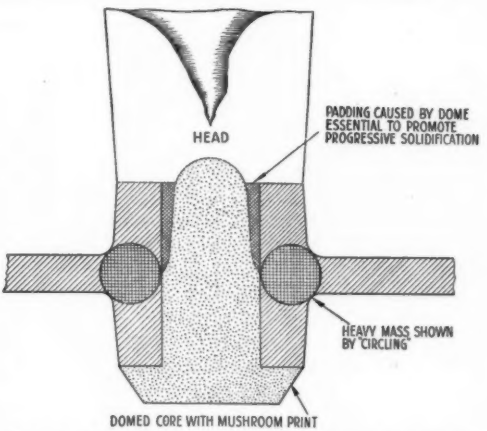
HEAD
PADDING CAUSED BY DOME ESSENTIAL TO PROMOTE PROGRESSIVE SOLIDIFICATION
HEAVY MASS SHOWN BY CIRCLING
DOMED CORE WITH MUSHROOM PRINT

FIG. 2.—UNUSUAL CORE SHAPE USED TO ADVANTAGE.

(3) *Supercooling*

The phenomena of supercooling is faily well understood. Undercooling of alloys does occur, but to what degree has not been ascertained. Rapid cooling encourages supercooling, and thus in thin sections a considerable degree of supercooling may take place. The fluidity of an alloy under these conditions may well affect feeding efficiency. Perhaps some research worker may eventually be able to shed some light on this unknown variable.

(4) *Latent Heat of Fusion*

On crystallisation heat is evolved because of the change of state from liquid to solid and the values

Some Notes on Feeding

for latent heat of fusion of some metals are given in Table I.—How latent heat of fusion affects feeding efficiency is a matter of conjecture, but it is of general interest to study the work of Bastien, on the relationship between fluidity latent heat, density, and the temperature of solidification.

Bastien revealed that:

$$\beta \propto \frac{L \times d}{F - 15}$$

where β = length of spiral cast at a constant temperature above the solidus

L = latent heat of fusion

d = density

F = temperature of solidification

15 = temperature of mould. (All temperatures in deg. C.)

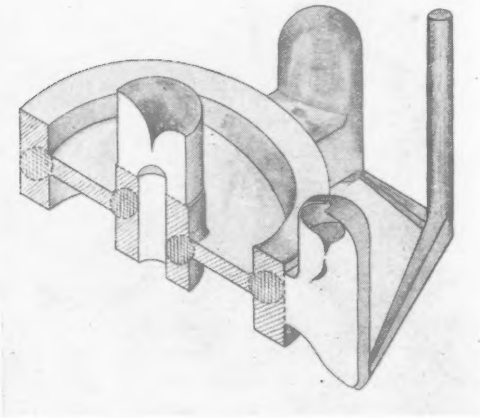

FIG. 3.—SHOWING APPLICATION OF DIRECTIONAL SOLIDIFICATION.

Table I gives the constants used. Order of fluidity by calculation is Zn, Sn, Sb, Cd, Al, Pb, and actual experimental work using the spiral test piece gave the fluidity order of Sn, Zn, Sb, Cd, Al, Pb.

(5) *Specific Heat*

Again reference should be made to the work of Bastien on fluidity. He revealed that:—

$$\beta \propto c \times d$$

Where β = length of spiral cast at a constant temperature above the solidus

c = specific heat

d = density

TABLE I.—*Constants Used in the Latent Heat of Fusion of Various Metals*

Metal.	d	e	L	L×D	$\frac{L \times d}{F-15}$
Al ..	2.3	0.22	79.6	183	0.29
Zn ..	6.9	0.12	26.5	182	0.46
Sb ..	6.5	0.07	41	256	0.41
Cd ..	8.6	0.06	13	112	0.37
Sn ..	6.9	0.05	14	96	0.44
Pb ..	10.8	0.03	5.5	59	0.18

TABLE II.—*Constants Used in Connection with Specific Heat.*

Metal.	e	d	$e \times d$
Sn	0.05	7.3	0.37
Sb	0.07	6.6	0.46
Pb	0.03	11.3	0.34
Cd	0.06	8.6	0.55

Table II shows the constants used. The experimental work confirmed the calculations made by the investigator. Fluidity is probably the most important factor in feeding efficiency and therefore this study of specific heat should not be neglected.

(6) *Gas Content*

The fact that gases are present in a greater or less degree depending on certain variables is accepted. As gas is more soluble in liquid metals than their solids, it must under normal conditions mostly come out of solution on solidification. A great amount of literature has been written on the solubilities of certain gases, but this Paper is limited to feeding, and this section to the effect the presence of gas in the metal has on its feeding characteristics. Actually what occurs in solidification is that crystallisation begins to take place and crystal growth commences. As the relative concentration of gas becomes so high in the solidifying portion as to be supersaturated, then some of the gas is given off. More and more gas is given off from surrounding material that is solidifying, and as this bubble growth is taking place, so is crystallisation proceeding. The bubbles form round the crystals which have given birth to this gas, and as a result are forming continuously in the interstices of ingrowing crystals.

As crystal growth proceeds, these interdendritic voids are formed because the evolved gas sets up an equilibrium with the feeding pressure. Feeding liquid is prevented from entering these voids because of the positive pressure set up by the evolved gas. This is a complex problem and further reference will be given to this aspect under the heading "Flow of Metal." Crystal and bubble growth take place simultaneously, and unless the gas pressure in the voids is overcome and finally filled or partially filled by feeding metal, then crystal growth will finally seal in the gas bubble, giving rise to sponginess and increasing porosity. All this theoretical explanation has been carefully proved by experiments and many references can be made on this subject.

The presence of gas in an alloy now becomes one more variable which controls feeding efficiency. Such things then as good melting and fluxing practice have

an indirect bearing on feeding efficiency. Obviously, bubble growth only takes place in gassy metal, and therefore the statement concerning bubble growth should be treated as very general, and must vary according to the quantity of gas evolved during solidification. Certain alloys have been shown to receive beneficial results because of the presence of a small quantity of gas. Instead of local sponginess in certain areas, an optimum gas content breaks this up into very minute porosity throughout the casting. The question of whether to aim for efficient feeding or optimum gas content is debatable, but the former is more practicable.

(7) *Forms of Shrinkage Cavities*

There are several forms of shrinkage which occur in castings, whether made in steel, aluminium, magnesium or bronze. Broadly speaking these can, however, be split into two main groups:—(*a*) macro- and (*b*) microshrinkage.

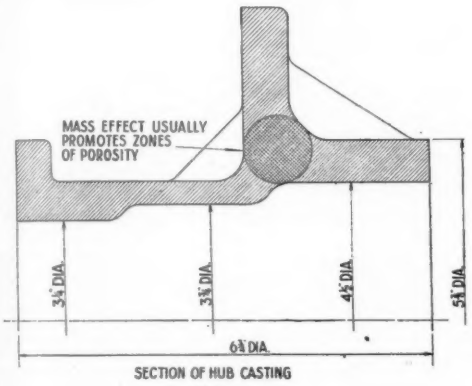

FIG. 4.

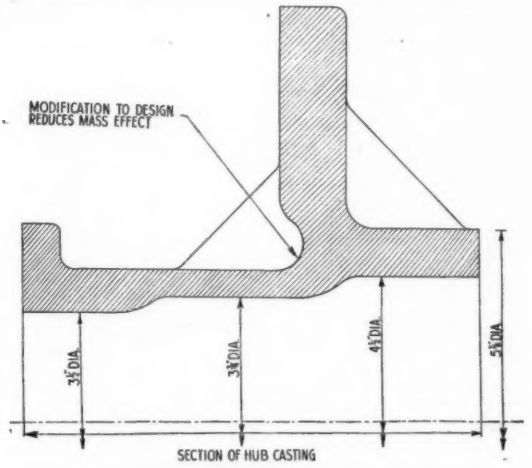

FIG. 5.

FIGS. 4 AND 5 SHOW MODIFIED DESIGN USING THE HEUVER METHOD.

(*a*) *Macroshrinkage*:

This form of shrinkage is a result of shortage of feed metal, and the result, cavities, visible to the naked eye, varying in size of course as related to the shortage of feed metal. This shortage of feed metal may not however be a result of small feeder heads. Balanced systems of feeding are essential in good feeding technique, and unless this is established, only excessive amounts of feeder heads will overcome the trouble. Having balanced feeding systems it may be said generally that major shrinkage can be overcome by correct gating and feeding technique.

(*b*) *Microshrinkage*:

This looseness of structure is a result of interdendritic voids, and many variables control its occurrence and concentration. These variables are such things as solidification range, contour of liquidus and solidus, gas content, etc. The methods of overcoming this porosity depend on its cause and are studied in other paragraphs in this Paper.

Other forms of shrinkage do occur. For instance, centre line shrinkage in steel could hardly be termed microshrinkage, and yet it is a result of the meeting of ingrowing crystals. This midwall shrinkage consists of interconnected voids occurring more or less in the centre of a solidfying mass where side wall effects have been pronounced. This centre line shrinkage has two characteristics (*a*) position, and (*b*) direction. In vertical planes this shrinkage occurs in the centre, whilst the more a section approaches the horizontal the more the tendency of this "centre line" shrinkage to move nearer the top face. The formation of these voids is usually of the V type, and points away from the feeder head. The influence of centre line shrinkage of course is to decrease mechanical properties and also to make castings unsound to hydraulic pressure tests. This centre line shrinkage can usually be overcome by using the general principles of directional solidification. A form of macroshrinkage presenting many foundry problems is caused by hot spots. The occurrence of hot spots is a continual source of annoyance, and the use of chills or possible re-design can be used to help reduce the problem.

(B) Directional Solidification and Temperature Gradients

(1) *Principle of Directional Solidification.*

A considerable amount of literature has been written on directional solidification. Briefly it consists of pro-

Some Notes on Feeding

gressive solidification at the point most distant from a feeder head, final solidification to take place at the base of the head. This simple statement, is, however, not always easy to achieve because of such factors as casting design, method of casting and feeding most practicable, occurrence of hot spots, etc. In itself, directional solidification can be broken down into fundamental basic principles, and some of these will be considered in the following paragraphs. Some proved and recommended methods of achieving progressive solidification will be mentioned, but it is not possible to cover all methods of obtaining this. The better known include top gating and feeding, step gating, and pouring directly into the riser by means of pencil gates.

(2) *Casting design and the Heuver method of planning the feeding method.*

An example of a common casting which although relatively simple in design gives considerable trouble because of shrinkage cavities and porosity showing after machining, is a gear blank as shown in Fig. 1. Using Heuver's circle method of illustrating the thickest section which will require feeding, it is found that the portion of the casting connected to the web, both in the boss and rim, is greater than in any other portion. If the orthodox method of feeding, *i.e.*, top heads be used, these must be heeled down in relation to the circle indicating the maximum section. The method is shown in Fig. 1. Note the unusual shape of the centre core in Fig. 2 necessary to give even section to the maximum section to be fed. With the use of this method, however, whilst the centre boss was always found to be sound, a considerable amount of porosity occurred in the rim. To overcome this, the principle of directional solidification was used and two whirlgate atmospheric heads were substituted for the four top heads on the rim. Fig. 3 shows the method and illustrates a section of the rim and head indicating the Heuver method of "circling" to show where it is essential for maximum feed. The use of this method of circling is useful to designers of castings as well as to the foundryman, and could be used by those who understand feeding technique to prevent problems ever reaching the foundry. Figs. 4 and 5 illustrate an example of a modified design of hub casting using the Heuver principle.

(3) *Pronouncing directional solidification by the use of insulating material for feeder heads*:[1]

A casting with a 60 per cent. yield required a feeder head of 40 per cent., this feeder head being made up of (*a*) the mass of metal required to offset premature freezing of the head, and (*b*) the quantity of metal to compensate for liquid shrinkage in the alloy. Assuming that this latter requirement is 10 per cent., then 80 per cent. of the feeder head is used to prevent by mass effect, its premature freezing. This means that only 20 per cent. of the feeder head is used for liquid shrinkage requirements. A simple deduction from this observation was that if the rate of solidification of the feeder head could be retarded, then the mass of metal required to offset premature freezing could be reduced.

One method of doing this is to use insulating pads round the risers. This has been done in steel by using a 10 per cent. sawdust addition to the sand, and in bronzes by the use of gypsum pads. Feeder efficiency is greatly increased, and although no figures are available for steel, yields of over 80 per cent. have been recorded with the bronzes. This idea is particularly interesting for the non-ferrous founder who often in his efforts to reduce turbulent gating is faced with having to use very large top heads in order to promote progressive feeding. Manganese and aluminium bronze castings are noteworthy in this respect, and gypsum insulated heads have proved most effective in increasing feeder efficiency and improving yield figures in some cases by as much as 75 per cent. of the previous figures. Because of the very slow lateral solidification of the feeder head, the shrinkage cavity in insulated feeders is globular and sometimes practically flat bottomed, thus reducing wastage to a minimum.

(4) *The use of exothermic material* (*a*) *in, and* (*b*) *round feeder heads*:

Various liquefiers and feeder powders are on the market to-day for use in ferrous and non-ferrous feeding technique. Two new advances in America, however, would appear to have great advantages over these materials. The first is used inside a feeder head and the second is moulded round the feeder but can also be used inside.

(*a*) *Exothermic compounds to be used inside a feeder head*:

The preliminary work on this subject was completed at the Boston Naval Dockyard. Tests were completed for steel and monel metal and illustrates the usage of exothermic materials in concentrated form to risers, thus providing great heat to promote directional solidification.

In exothermic reactions the properly sized powders of oxides of metals react with aluminium powder to produce the metal of the oxide, aluminium oxide, and, of course, the generation of intense heat because of this chemical reaction. The chemical formulæ for the general reactions for steel, Monel metal and bronze applications would involve some or combinations of the following:—

$$3\,Fe_3O_4 + 8\,Al = 4\,Al_2O_3 + 9\,Fe + \text{Heat.}$$
$$3\,Ni\,O + 2\,Al = Al_2O_3 + 3\,Ni + \text{Heat.}$$
$$3\,Co\,O + 2\,Al = Al_2O_3 + 3\,Cu + \text{Heat.}$$

This type of reaction provides the two basic anti-shrinkage aids, *i.e.*, the production of superheated metal in the riser, where heat is most desirable and production of an insulating material on the surface of the riser to prevent heat radiation. The method used by these investigators was to fill the feeder head with exothermic compound instead of the liquid alloy. This resulted in superheated metal of very high fluidity being in the heads. On final solidification the heads were found to be of the flat-bottomed type, and yields

(*Continued on page* 303)

(*Continued from page* 302)

of 80 per cent. were obtainable. More work has still to be done on this subject, and consequently its practical value has not been fully investigated. Its use, however, may be limited to one of alloy composition, but undoubtedly this investigation is a step in the right direction.

(*b*) The use of exothermic material moulded round the feeder head[3]:

The recent development of a compound known as Thermotomic in America promises to cause some revision of feeding methods. The compound developed by the Pittsburgh Metals Purifying Company relates to an exothermic material, which it is claimed generates intense heat over a period which can be controlled up to four or five hours. Once the material has burned it becomes refractory, quite capable of standing up to temperatures above that of steel.

The reactive material consists of a composition that generates heat as a result of the oxidation of a metal by one or more oxides modified to control the rate of heat evolution. If this material is moulded round the feeder head, the amount of heat evolved will either result in the maintenance of the casting temperature within the head or raise it above this temperature, dependent on the rate of heat evolution. As a result of this a metal of high fluidity and constant composition is maintained within the feeder head. A further modification can be made to the feeder head in that the connection of the head can be considerably reduced in size by the use of this exothermic material. The development of "Thermotomic" compound would appear to have considerable possibilities in that it makes it possible to retard the solidification rate of a thin section so that feeding can take place through this section. Further reference will be made at a later stage of the Paper when describing the future use of "Thermotomic" or a derivative of this "compound" for simplifying feeding methods.

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2 Insulating Pads and Riser Sleeves for Bronze Castings. H. F. Taylor and W. C. Wick. American Foundryman, March, 1946.
3 Feeding of Castings aided by New Compound. J. C. Sullivan. The Foundry, June, 1946.

(*To be continued.*)

W. H. Whittle Foundation

The Institute of Vitreous Enamellers announces that entries for the competition for the Whittle Silver Medal should be received by the Hon. Secretary before August 31 next. The medal carries a cash prize of 10 guineas and other prizes, to be awarded for a Paper on any subject associated with the enamelling industry. The purpose of the competition is to encourage junior chemists and other technicians in the industry to put their ideas into the form of a written Paper. All entries are to be submitted to the Hon. Secretary of the Institute. Mr. W. Thomas, Ebury Chambers, 74, High Street, Rickmansworth, Herts.

John Brown & Company's Orders

Further Offer for A. C. Wickman's Shares

The shipyard and engineering works at Clydebank have been very fully employed during the year and continue so to be, says Lord Aberconway, the chairman, in his statement with the report of John Brown & Company, Limited. Work in hand during the year included the reconditioning of the Cunard White Star liners Queen Elizabeth and Queen Mary. For the Admiralty there was continued the construction of H.M. cruiser Tiger and of three destroyers. For private shipowners there were building a large passenger ship, five passenger-cargo ships, five refrigerated-cargo ships, and two cross-Channel ships. In addition, valuable contracts were undertaken for water turbines for Scottish hydro-electric schemes and for various reconditioning work. The company has entered into a working agreement with the Escher Wyss Engineering Works of Zürich, Switzerland, for the closed-cycle type of gas turbine which the company intends to manufacture.

It was reported last week that John Brown & Company had acquired upwards of 60 per cent. of the 5s. ordinary shares of A. C. Wickman, Limited, machine-tool makers, of Coventry. John Brown & Company has offered to acquire the remaining ordinary shares at the price, namely, 11s. 9d. per share, paid to holders of the shares already acquired. Last March it was disclosed that John Brown & Company had acquired a substantial interest in, and would be represented on the board of, A. C. Wickman, Limited, but no information was given as to the number or price of the shares involved in this deal.

Obituary

MR. JAMES ROBERTSON, superintendent engineer of the City Line, Glasgow, who died recently, was widely known in shipbuilding and shiprepairing circles in Glasgow, and on the Tyne and the Mersey. He was 63 years of age.

MR. SIDNEY LINTON BRUNTON, formerly a director of Joseph Sankey & Sons, Limited, Wolverhampton, died recently. He became general manager of their Hadley Castle Works. He had been at the works from its inception in 1910, until his retirement some years ago.

MR. THOMAS WILLETTS ADSHEAD, who has died at the age of 84, was for many years managing director of Thos. Adshead & Sons, foundrymen, etc., of Dudley, Worcs. He was a member of the Dudley Town Council for 45 years continuously, and was Mayor of the town in 1918-19.

MR. LOUIS M'EWAN MILLER, a well-known figure in Scottish shipbuilding circles, died in Glasgow on July 16, after a short illness. He was 67. Mr. Miller founded in 1920 the Miller Insulation Company, Scotstoun, of which he was chairman. He was responsible for many new developments in refrigeration and heat insulation which his company has carried out for various shipping lines.

Imports and Exports of Iron and Steel

Board of Trade Returns for June

The following tables, based on Board of Trade returns, give figures of imports and exports of iron and steel in June and in the first six months of 1947. Figures for the corresponding period of 1938 are given for purposes of comparison.

Total Exports of Iron and Steel.

Destination.	June, 1947.	Six months ended June.	One-half of 1938.
	Tons.	Tons.	Tons.
Eire	6,864	30,837	27,860
Channel Islands	696	3,211	3,708
Malta and Gozo	150	1,843	1,152
Cyprus	531	1,504	828
Palestine	4,299	21,099	4,036
British West Africa	2,614	22,586	24,872
Union of South Africa	16,691	80,843	115,544
Northern Rhodesia	1,372	3,913	10,288
Southern Rhodesia	2,632	10,049	18,106
British East Africa	8,713	19,796	12,966
British India	7,222	51,348	79,340
Burma	4,254	24,309	9,256
British Malaya	2,651	19,256	33,292
Ceylon	822	6,125	13,016
Hong Kong	1,460	11,144	11,798
Australia	2,733	19,615	85,452
New Zealand	3,018	25,248	65,942
Canada	2,261	7,163	42,704
British West India Islands	3,309	16,738	22,126
Anglo-Egyptian Sudan	1,006	5,800	4,146
Other British Countries	3,162	19,980	8,990
Soviet Union	—	1,601	2,174
Finland	5,405	23,198	8,804
Sweden	11,014	46,367	5,987
Norway	4,386	25,661	10,136
Iceland	365	3,813	330
Denmark	7,651	51,362	43,628
Poland	42	440	1,244
Netherlands	6,808	50,554	25,780
Belgium	1,601	11,942	10,162
Luxemburg	10	598	52
France	1,312	11,016	6,694
Switzerland	1,761	8,454	1,391
Portugal	2,089	8,525	3,856
Spain	549	2,755	3,882
Italy	1,108	4,330	2,570
Greece	2,335	9,038	876
Turkey	1,632	7,856	6,878
Dutch East Indies	2,171	12,038	13,654
Dutch West India Islands	1,074	5,387	1,232
Belgian Congo	31	928	152
Portuguese East Africa	908	2,718	7,110
Syria	423	1,798	1,303
Egypt	2,450	23,222	17,204
Iraq	5,955	31,150	12,870
Iran	4,579	25,525	55,190
China	2,376	23,068	11,255
U.S.A.	369	5,966	1,094
Colombia	398	4,778	1,912
Venezuela	4,321	15,295	2,338
Ecuador	630	2,862	796
Peru	137	2,288	1,516
Chile	1,653	4,860	3,146
Brazil	382	14,849	8,496
Uruguay	710	4,989	3,794
Argentine	6,336	39,143	39,678
Other Foreign Countries	4,834	29,045	45,356
Total	164,265	919,826	957,938

IT IS UNDERSTOOD that A. Reyrolle & Company, Limited, Hebburn, Co. Durham, have secured a contract valued at 732,000 for the supply of switchboards for the Assam Dam, Egypt.

Total Imports of Iron and Steel.

From.	June, 1947.	Six months ended June.	One-half of 1938.
	Tons.	Tons.	Tons.
British India	—	929	77,816
Australia	5,020	33,883	18
Canada	10,519	85,384	58,688
Other British Countries	9	1,268	2,800
Sweden	1,161	5,471	44,898
Norway	2,251	13,432	16,888
Belgium	3,891	16,072	136,840
Luxemburg	690	2,707	29,300
France	53	967	128,674
U.S.A.	20,913	122,043	100,346
Other Foreign Countries	206	6,761	75,880
Total	44,713	288,917	672,135
Iron ore and concentrates—			
Manganiferous	—	43,619	31,142
Other sorts	436,495	3,034,607	2,550,935
Iron and steel, scrap and waste, fit only for the recovery of metal	38,750	158,357	316,102

Exports of Iron and Steel by Products.

Product.	June, 1947.	Six months ended June.	One-half of 1938.
	Tons.	Tons.	Tons.
Pig-iron	4,494	29,556	46,970
Ferro-alloys, etc.—			
Ferro-tungsten	91	424	258
Spiegeleisen and ferro-manganese	299	7,321	2,598
All other descriptions*	52	331	524
Ingots, blooms, billets and slabs	999	2,530	4,872
Iron bars and rods	711	2,598	1,598
Sheet and tinplate bars	2	46	6,190
Wire rods	76	1,128	1,590
Bright steel bars	2,593	13,990	3,294
Other steel bars and rods	12,067	74,307	51,006
Special steel	1,656	8,664	2,466
Angles, shapes and sections	8,029	51,602	33,437
Castings and forgings	562	2,936	810
Girders, beams, joists and pillars	3,242	16,755	16,736
Hoop and strip	2,806	19,346	18,688
Plates, ¼ in. thick and over	10,938	71,930	65,484
Black plates	2,025	14,265	7,270
Black sheets	4,851	22,468	31,756
Galvanised sheets	4,402	26,745	73,468
Tinplates	12,473	70,737	159,660
Tinned sheets	186	1,812	706
Terneplates	11	246	2,162
Decorated tinplates	12	459	2,184
Cast-iron pipes, up to 6-in. dia.	4,788	26,268	24,464
Do., over 6-in. dia.	4,163	18,693	21,482
Wrought-iron tubes	23,000	117,313	109,986
Radiators and central-heating boilers	362	1,869	2,014
Railway material	18,794	84,312	79,078
Wire	2,952	26,858	27,592
Cable and rope	2,393	13,627	8,200
Netting, fencing and mesh	1,663	8,140	4,708
Other wire manufactures	635	3,795	1,836
Nails, tacks, etc.	922	3,979	1,904
Rivets and washers	842	3,663	4,268
Wood screws	420	2,155	1,256
Bolts, nuts and metal screws	2,052	11,172	8,786
Stoves, grates, etc. (excl. gas)	655	3,080	3,503
Sanitary cisterns	97	382	1,406
Fencing material	704	3,773	2,566
Anchors, etc.	700	4,237	3,168
Chains	712	4,170	3,146
Springs	352	3,281	1,966
Hollow-ware	5,831	27,916	5,352
All other manufactures	19,651	110,947	107,554
Total	164,265	919,826	957,938

* The figures for 1938 are not completely comparable with those for subsequent years.

Company News

(Figures for previous year in brackets.)

Veritys—Dividend of 2½% (7½%).

E.K. Cole—Interim dividend of 8% (same).

Fisher & Ludlow—Dividend of 20% (15%).

Mather & Platt—Interim dividend of 4% (same).

Cozens & Sutcliffe (Holdings)—Dividend of 25%.

Aron Electricity Meter—Dividend of 15% (10%).

Hobbs, Hart & Company—Dividend of 6% (same).

Davies & Metcalfe—Interim dividend of 3% (same).

Christy Bros. & Company—Dividend of 17½% (same).

London Aluminium—Interim dividend of 25% (10%).

Fairbairn Lawson Combe Barbour—Dividend of 35% (25%).

Davy & United Engineering Company—Dividend of 7½% (same).

Vab Products—Final dividend of 7½%, making 12½% on increased capital (12½%).

Telephone Manufacturing Company—Final dividend of 6½%, making 9% (same).

Hepworth & Grandage—Dividend of 13¼% for nine months (17½% for 12 months).

Guest, Keen & Nettlefolds—Final dividend of 7%, making 11% on larger capital (11%).

Revo Electric Company—Final dividend of 12½% and bonus of 10%, making 27½% (20%).

Tipper Industries—Interim dividend of 7½%. (The company was made public in November last).

Duple Motor Bodies—Final dividend of 10.6%, making 14.2% for the 8½ months ended March 31.

Wolseley Sheep Shearing Machine Company—Net profit, £18,978 (£10,654); dividend of 12½% (same); forward, £26,022 (£22,943).

Macrome—Profit to February 28, £15,918 (£3,517); to tax and contingencies, £10,302 (£770); final dividend of 3%, making 6%; forward, £5,692 (£2,359).

Lyon & Lyon—Net profit for the year ended June 30, £11,917 (£10,990); to general reserve, £1,000 (£500); final dividend of 7½%, making 12½% (same); forward, £1,897 (£1,869).

Larmuth & Bulmer—Profit to March 31, after depreciation, etc., £7,476 (£12,551); to tax, £1,246 (£1,133); final dividend of 12½%, making 15% (12½%); forward, £14,747 (£13,467).

Midland Iron & Hardware Company (Cradley Heath)—Interim dividend of 100%, less tax (single payment of 100%, tax free). The company was made public last month.

Engineering & Lighting Equipment Company—Owing to the continuance of unsatisfactory conditions the directors regret that the half-yearly preference dividend must again be passed.

Associated British Engineering—Net revenue for the year ended March 31, £48,997 (£23,630); to dividend equalisation account, £20,000 (£3,000); dividend of 12% (same); forward, £18,933 (£8,587).

Banister, Walton & Company—Net profit for the year ended March 31, after tax and directors' fees, £31,751 (£31,399); final dividend of 20% and bonus of 5%, making 30% (same); forward, £41,503 (£29,987).

H. J. Baldwin & Company—Profit for the year ended March 31, after depreciation, etc., £39,840 (£26,327); taxation, £18,809 (£12,766); final dividend of 15%, making 25% (20%); forward, £26,804 (£21,173).

A.B.C. Coupler & Engineering Company—Net profit for the year ended September 30, after tax, etc., £8,146 (£6,694); dividend of 20% (15% and bonus of 2½%); general reserve, £4,797 (£3,433); forward, £1,480 (£1,613).

Permutit Company—Net profit for 1946, after depreciation, taxation, etc., £22,085 (£24,356); written off patents, licences and trade marks, £1,426 (£527); dividend of 10% (same) and bonus of 2½% (same); forward, £50,739 (£38,396).

Incandescent Heat Company—Trading profit for 1946, including dividend from subsidiary company, £18,980; to directors' fees, £533; depreciation, £3,015; taxation, £6,800; net profit, £8,632; dividend of 5%; forward, £20,520 (£15,646).

Aluminium Castings Company—Net profit to March 30, £21,181 (£2,703); to tax, £2,744 (nil); written off capital issue expenses, £2,571 (nil); preferred ordinary dividend of 15⅝% (nil); ordinary dividend of 32½% (nil); forward, £4,185 (£3,774).

Peto Scott Electrical Instruments—Operating profit to March 31, £34,286 (£41,310); dividend from subsidiary, nil (£1,100); tax, £25,117 (£33,665); W.D.C., nil (£14); written off new issue expenses, nil (£1,177); net profit, £9,169 (£7,554); dividend of 25% (same); forward, £13,433 (£10,451).

Gjers, Mills & Company—Trading profit for 1946, £42,779 (£76,488); to interest, £2,090 (£300); directors' fees, £1,050 (same); tax and N.D.C., £16,750 (£37,500); depreciation, £6,000 (same); deferred repairs and contingencies, £5,000 (£13,000); dividend of 8% (12½%); forward, £41,676 (£41,667).

W. & T. Avery—Net profit for the year ended March 31, £202,067 (£147,119); final dividend of 10%, making 15% (same) and bonus of 5% (nil); to reconversion and development reserve, £50,000 (same); research reserve, £50,000 (nil); general reserve, nil (£20,000); forward, £71,261 (£71,295).

Spurling Motor Bodies—Net profit of group for the year ended February 28, £215,341 (£91,608); to tax, £128,998 (£56,760); off investments, nil (£9,994); off goodwill, £4,000 (nil); general reserve, £3,000 (same); employees' welfare, £2,000 (nil); final dividend of 25% (12½% and bonus of 2½%), making 35% (15%).

John Brown & Company—Net profit for the year ended March 31, £508,795 (£407,264), after debenture and other interest (gross) £19,574 (£19,995), depreciation £66,685 (£57,374), directors' fees £5,500 (£6,799), and

debenture trustees' fees £138 (same); final dividend of 11d. (8d.), tax free, making 1s. 3d., or 12½% (10%), tax free; forward, £376,232 (£238,809).

Yorkshire Amalgamated Products—Trading profit, after management expenses, etc., £16,023 (£13,772); to depreciation, £5,123 (£4,920); land wastage, £1,000 (same); debenture and loan interest, £2,995 (£3,064); directors' fees, £434 (£625); tax, £4,615 (£3,820); net profit, £1,856 (£343); to staff fund, nil (£250); dividend of 2½% (5%); forward, £12,063 (£11,950).

Crossley-Premier Engines—Profit to April 30, including adjustments in respect of contracts completed in previous years and after depreciation, £39,969 (£85,973); to income tax, £17,000 (£39,500); N.D.C. and profits tax, £2,800 (£4,700); net profit, £20,169 (£41,773); to general reserve, £6,500 (£7,000); staff superannuation reserve, nil (£500); dividend of 12½% (25%); forward, £23,481 (£22,942).

Darlington & Simpson Rolling Mills—Trading profit for the year ended March 31, £114,577 (£58,199); other income, £399 (£837); to directors' fees, £1,100 (£1,250); loan interest, £16,944 (£3,212); depreciation, £32,964 (£18,308); N.D.C. and profits tax, less tax provision (£3,500) no longer required, £1,300 (£17,000); net profit, £62,668 (£19,266); to general reserve, £27,469 (nil); dividend of 9% (5%); forward, £31,188 (£19,419).

Williams & Williams—Trading profit for the year ended April 30, after providing for E.P.T., profits tax, etc., £134,772 (£127,110); to directors' fees, £1,750 (£1,900); depreciation, £34,241 (£31,698); debenture interest, £3,186 (£3,413); sinking fund for redemption of debentures, £4,814 (£4,587); further provision for taxation, £47,500 (£60,664); general reserve, £20,000 (£2,568); dividend of 15% (same); forward, £30,103 (£28,176).

Allied Ironfounders—Dividends declared by subsidiary companies for the year ended March 31, £279,453 (£225,018); investment income, £22,856 (£17,696); refund of income tax £4,450 (£5,843); net profit, £299,277 (£242,494); to general reserve, £50,000 (£43,927); pensions reserve, £30,000 (nil); preference dividend, £38,292; final ordinary dividend of 12½% (7½%), making 17½% (12½%); forward, £316,818 (£303,442).

B. Elliott & Company—Trading profit for the year ended March 31, £100,279 (£63,552); taxation, £49,049 (£34,995); depreciation, £4,004 (£2,635); issue expenses, £6,034; directors' fees, £437 (£65); expenses of acquisition of property, £407 (£470); net profit, £40,346 (£25,387); to 4½% preference dividend accrued to March 31, 1947, £170 (nil); ordinary dividend of 100% (100% on smaller capital), £24,750 (£22,000); forward, £141,172 (£125,745).

Briton Ferry Steel Company—Profit for the year ended March 29, after £50,000 (same) for depreciation, £205,282 (£138,832); officials' and staff bonus, £9,009 (£4,270); victory bonuses to employees, £1,970 (£10,736); taxation, £100,000 (£66,000); net profit, £94,303 (£57,826); to reserve for modernisation and contingencies, £35,000 (£30,488); general reserve, £20,000 (nil); final dividend of 12½%, making 15% (10%); forward, £57,449 (£54,916).

British Steel Constructions (Birmingham)—Profit for the year ended August 31, £19,099 (£23,158); to income tax, £8,580 (£13,824); reserve, £10,000 (£8,000); forward, £2,551 (£2,031, after dividend of 7½%, £4,878, and war damage contributions, £238). The report states that the surplus after providing for tax on the group as a whole was £2,960 only, and, in view of the need to conserve the group's resources, the directors are unable to recommend payment of a dividend.

Edgar Allen & Company—Trading profit to March 29, £115,339 (£30,927); interest and dividends, £13,044 (£12,690); profit of subsidiary companies, £5,149 (£3,599); to depreciation, £38,718 (£36,721); director's fee, £300 (same); leaving £94,514 (£10,195); E.P.T. refund, £6,050 (£48,000); reserve against investment in subsidiary company not required, £25,000 (nil); taxation, £42,050 (£9,900); contingencies, £40,000 (nil); dividend of 12½% (same); reserve, £20,000 (same); forward, £45,466 (£49,954).

Hick, Hargreaves & Company—Trading profit, after taxation, etc., and charging £28,132 (nil); staff pension benefits, for the year to March 31, £68,918 (£60,334); bank interest, nil (£133); interest on investment and tax reserve certificates, £331 (£673); to depreciation, £16,508 (£18,241); net profit, £52,742 (£42,899); final dividend of 8%, making 10% (same); reserve, £20,000 (£10,000 to contingencies reserve); employees' benevolent and welfare fund, £3,000 (£2,000); forward (subject to directors' fees), £11,265 (£7,798).

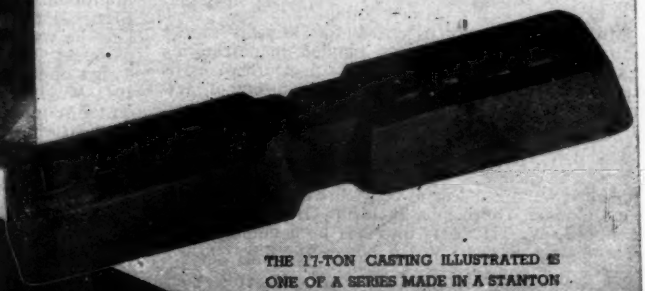
W. T. Henley's Telegraph Works Company—Trading profit for 1946, including income from investments, and after providing for E.P.T. and overseas taxation, bad debts and contingencies, £633,482 (£582,829); to directors' fees, £8,750 (same); auditors' fees, £1,800 (£1,500); depreciation, £94,973 (£85,849); U.K. income tax, £274,406 (£273,294); net profit, £253,553 (£213,436); post-war contingencies reserve, £75,000 (same); staff pension fund, £10,000 (nil); final dividend of 10% (same) and cash bonus of 5% (same); forward, £413,822 (£393,219).

General Electric Company—Profit on trading and income from investments to March 31, after making full provision for E.P.T. and profits tax, £2,270,965 (£2,300,554); depreciation, £492,276 (£449,788); directors' fees, £3,000 (same); pension fund, £130,488 (£121,353); income tax, £740,000 (£770,000); net profit, £905,201 (£956,413); to preference dividends, £185,361 (£174,800); general reserve, £320,678 (nil); deferred repairs and rehabilitation, nil (£350,000); ordinary dividend of 10% (same) and bonus of 7½% (same); forward, £986,859 (£991,790).

Glacier Metal Company—Trading profit for the year ended February 28, £117,958 (£71,717); interest, etc., received, £686 (£1,045); to depreciation, £16,503 (£18,359); directors' salaries and expenses, £8,979 (previous years charged before arriving at balance of trading profit); directors' fees, £625 (£539); war damage, nil (£990); net profit, £92,537 (£52,874); provisions not required, nil (£44,020); profits on sales of capital assets, £858 (£12,289); to deferred repairs, £13,565 (£30,905); taxation, £27,940 (£35,412); preference dividend, less tax, £5,544 (£3,895); general reserve, £40,000 (£22,000); ordinary dividend of 7½% (same); forward, £19,199 (£20,670).

STANTON-DALE
REFINED PIG IRON

Manufactured to guaranteed analyses in seven standard grades. Also obtainable to individual specification



THE 17-TON CASTING ILLUSTRATED IS ONE OF A SERIES MADE IN A STANTON FOUNDRY FROM STANTON DALE IRON

1. Core being lowered into mould
2. Pouring the metal
3. Finished casting in transit

The
STANTON IRONWORKS
COMPANY LIMITED
NEAR NOTTINGHAM

Personal

MR. H. E. G. WEST, managing director of Newton Chambers & Company, Limited, Thorncliffe, Sheffield, will make a business trip to the United States in October.

MR. R. L. EVANS, who has been secretary of Rugby Portland Cement Company Limited for many years, has been elected a directo.. He retains his position as secretary.

DR. H. O'NEILL, chief metallurgist to the L.M.S. Railway Company, has been appointed Professor of Metallurgy at the University of Swansea, in succession to DR. C. A. EDWARDS.

MR. T. THOMPSON, who has been in the service of British Insulated Callender's Cables, Limited, for more than 36 years, has retired at the age of 72. He recently received the B.E.M. for his work at Prescot during the war.

MR. G. H. PAWSEY has retired after 48 years' service with A. Reyrolle & Company, Limited, manufacturing electrical engineers, of Hebburn, Co. Durham. His duties have been connected with the starting of new employees. Mr. Pawsey has received a presentation to mark his retirement.

MR. B. W. ROOME, welfare officer and labour manager of a chemical firm in Morecambe, has been appointed welfare officer to Newton Chambers & Company, Limited, Thorncliffe, Sheffield. His assistant will be MR. J. W. TRICKETT, who has been employed by the company since he was a boy.

MR. AND MRS. JOSEPH DYEHOUSE celebrated their golden wedding on July 17. Mr. Dyehouse was for 20 years works manager for the Oriental Tube Company, Limited, West Bromwich, before entering business on his own account at Smethwick as the British Tube Mills, Limited. He was also a director of Accles & Pollock, Limited, Oldbury. He retired from business last year.

MR. LESLIE GAMAGE, joint managing director of the General Electric Company, Limited, has been re-elected chairman of the British Export Trade Research Organisation for the ensuing year. SIR PERCY LISTER, of R. A. Lister & Company, Limited, engineers and iron-founders, of Dursley, Glos, is succeeded as deputy chairman by MR. JOHN RYAN, of the Metal Box Company, Limited.

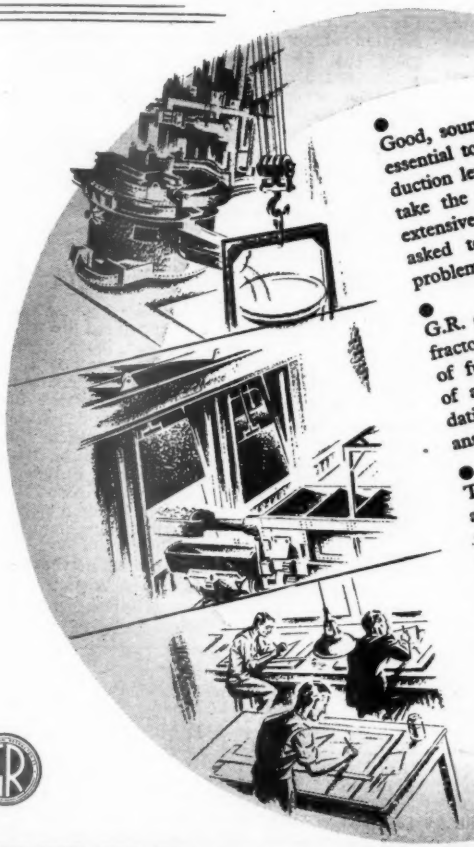
MR. W. H. TILDESLEY, chairman of W. H. Tildesley, Limited, manufacturers of drop forgings, stampings and pressings, of Willenhall, Staffs, celebrated his 92nd birthday on July 16. It is thought that he is probably the oldest active business man in the town and the oldest Rotarian in the country. Mr. Tildesley still drives to business almost every day. His wife is 90 years of age and they have been married for 66 years.

MR. B. CHETWYND TALBOT, son of Mr. Benjamin Talbot, chairman of the two companies, has been appointed deputy chairman and general manager of the South Durham Steel & Iron Company, Limited, and the Cargo Fleet Iron Company, Limited. The resignation of SIR RALPH FREEMAN from both boards has been announced with regret. MR. JOHN E. SHEPHERD and MR. ASTLEY BARTON have been appointed directors of the South Durham Steel & Iron Company, while the names of two prominent shipbuilders, SIR WILLIAM GRAY, Bt., and MR. STEPHEN FURNESS, have been added to the board of the Cargo Fleet Iron Company.

MR. G. A. JUHLIN has resigned his position as chief electrical engineer of the Metropolitan-Vickers Electrical Company, Limited. He will continue to act in an advisory capacity to the managing director and remains a director of the parent company and of the Metropolitan-Vickers Electrical Export Company, Limited. Mr. Juhlin, who was born and educated in Sweden, joined the firm of Dick Kerr & Company, Preston, in 1902. For eight years he was chief a.c. design engineer to this company. In 1915 he joined Metropolitan-Vickers (then the British Westinghouse Electrical & Manufacturing Company), and two years later he was appointed chief engineer of the plant department, in which capacity he was responsible for the design of the company's heavy electrical products. In 1941 Mr. Juhlin was appointed chief electrical engineer on the retirement of Mr. J. S. Peck. He was elected to the board in the following year; he had been a director of the Metropolitan-Vickers Electrical Export Company since 1935. Mr. Juhlin has taken a prominent part in the activities of the Institution of Electrical Engineers, to which he has contributed a number of Papers, chiefly on electrical machine design. He was chairman of the North-Western centre of the Institution for 1923-24.

DR. C. DANNATT has been appointed chief electrical engineer of the Metropolitan-Vickers Electrical Company, Limited, in succession to Mr. G. A. Juhlin. Dr. Dannatt received his technical education under Prof. W. M. Thornton, at Armstrong College, Newcastle-upon-Tyne, from which he graduated in electrical engineering in 1921. He joined Metropolitan-Vickers as a college apprentice in that year and subsequently entered the electrical and magnetic section of the research department, taking charge of the section in 1924. His activities have been mainly concerned with engineering investigations; he is a recognised authority on electrical measurements, especially in relation to magnetism and the behaviour of dielectrics. Dr. Dannatt is the author of numerous articles and Papers to scientific and engineering societies and is principal author of "Electrical Power Transmission and Interconnection." In 1936 he was awarded the degree of D.Sc. by the University of Durham. He was appointed to the chair of electrical engineering in the University of Birmingham in August, 1940, but, at the request of the Admiralty, he continued part-time activities with the Metropolitan-Vickers Company. In the New Year Honours List of 1943 he was awarded the O.B.E. for contributions to naval gunnery. Dr. Dannatt returned to Metropolitan-Vickers as assistant to the chief electrical engineer, and in the following year he was appointed deputy chief electrical engineer.

Practical men give practical help wherever Refractories are used



● Good, sound refractories properly applied are essential to industries operating at record production levels. General Refractories not only take the greatest care in manufacturing their extensive range of products but are frequently asked to assist in the solution of difficult problems of selection and application.

● G.R. engineers—supported by a range of refractories covering the requirements of all types of furnaces, and familiar with a wide variety of applications—are able to make recommendations which ensure the most advantageous answer to a user's problem.

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192

Raw Material Markets

Iron and Steel

Whereas steel production has been raised well above the 1946 figures, the output of pig-iron still compares unfavourably with the corresponding statistics for last year. The position has, in fact, become extremely difficult, but it is learnt that immediate steps are being taken to increase blast-furnace production in the near future. Meanwhile, steelmakers are getting barely sufficient basic iron to keep the furnaces going and foundrymen are working on reduced rations. Shortage of pig-iron is restricting the output of castings at a most inconvenient moment, but foundrymen are more or less helpless to achieve more satisfactory outputs until the necessary pig-iron is forthcoming.

Provision of material for the re-rolling industry is an ever-present problem. Hitherto the scarcity of the smaller sizes of billets has been the chief subject of complaint, but some of the mills engaged on light sheets are now unable to maintain full production owing to the lack of sheet bars. This is all the more lamentable since the gap between the supply and the demand for sheets is wider than in the case of any other class of finished steel. The supply of the heavier sizes of billets is a little better, but the position all round is very difficult and the only hope of early relief depends upon the extent of imports from the Continent or the United States.

The strength of the market for steel at home and abroad is wholly unimpaired, and the tendency in official circles seems to be to impose further restrictions on the export trade. The priority groups are calling for very big tonnages and their requirements are being promptly met. Shipbuilders, too, are faring better than had been anticipated. They are not getting all the material they need, but are carrying on at a reduced tempo. Locomotive and wagon builders are accorded special priority and their rate of production is very heavy. Collieries are taking up big tonnages of steel for maintenance and mechanical developments. Wire mills are heavily booked and tube makers are calling for maximum tonnages of strip, etc.

Non-ferrous Metals

With the holiday season so close it is not surprising that business has been quiet. Demand for the most part is limited to material offered for the second half of August or early September, and it is quite obvious that all confidence in the sterling price structure of the virgin metals has evaporated. At what level buyers will again pluck up their courage it is hard to say, but one might hazard the guess that until the £100 level is reached copper will have few friends. Zinc at £70 is also very much overpriced against the world value, and is expected in due course, and under a system which allows commodities to find their economic level, to fall well below £50. As for lead at £90, it is hard to find words to express the feelings of those consumers whose fortunes are bound up with this metal.

Contracts Open

The dates given are the latest on which tenders will be accepted. The address is that from which forms of tender may be obtained.

Fife, August 6—Providing, laying and jointing of about 1,400 yds. of 4-in. spun-iron main with valves, etc., for the County Council. Mr. J. D. Cape, county engineer, County Offices, 34, Viewfield Terrace, Dunfermline.

Middlesbrough, August 18—Contract No. 18: Supply of 36-in. dia. concrete-lined cast-iron pipes and specials (fee £2 2s., returnable). Contract No. 19: Sluice valves and air valves for 36-in. dia. water main (fee £2 2s., returnable). Contract No. 32: Provision and erection of an electrically-driven centrifugal pumping plant (fee £5 5s., returnable), for the Tees Valley Water Board. Mr. T. S. R. Winter, engineer and general manager, The Tees Valley Water Board, Corporation Road, Middlesbrough.

Ystradgynlais, August 12—Construction of approx. 1,360 yds. of stoneware and cast-iron sewers, etc., for the Rural District Council. Mr. G. Swayne, consulting engineer, Victoria Street, Westminster, London, S.W.1. (Fee £5 5s., returnable.)

Heenan & Froude's Acquisition

Heenan & Froude, Limited, engineers and ironfounders, of Worcester, have acquired the whole of the shares in W. G. Bagnall, Limited, locomotive designers and builders, of Stafford. The new board of W. G. Bagnall, Limited, will be under the chairmanship of Mr. A. P. Good, chairman of Associated British Oil Engines, Limited, Heenan & Froude, Limited, and managing director of the Brush Electrical Engineering Company, Limited. The directors will be Mr. J. Fielding, managing director of Heenan & Froude, the Hon. A. C. Geddes, managing director of Associated British Oil Engines, Mr. I. A. Marriott, commercial director of the Brush Electrical Engineering Company and of Associated British Oil Engines, and Mr. C. Hill, a director of Heenan & Froude and of the Brush Electrical Engineering Company. Mr. W. O. J. Urry, secretary of Heenan & Froude, Limited, will be secretary of W. G. Bagnall, Limited.

Zinc Corporation—Accounts for 1946 show gross value of products, £2,675,347 (£2,136,132); to mining, milling, etc., £1,624,360 (£1,328,873); mine development, £229,944 (£148,744); administration, £50,909 (£39,358); mining royalty, £55,588 (£25,840), leaving £714,546 (£593,317); interest, dividends, etc., £106.824 (£73,475), making £821.370 (£666,792); to tax provision, £438,863 (£328,846); directors' fees, £10,881 (£7,720); shaft sinking and new plant, £80,881 (£202,848); profits equalisation reserve, £36,000 (nil); preference dividends, £22,296 (£31,652); ordinary dividend of 7s. 6d. (2s. 6d.) per share or unit, less tax, £231,730; forward, £71,711 (£70,992).